SYNOPSIS

Relationship between Green House Gas Emissions, Trade Openness and Economic Growth – A Comparative Study between India and China

By

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Introduction

Economic development and trade caused green house gas emissions (Aye and Edoja, 2017**,** Shabaz et al, 2017 and Sun et al, 2019). The growth of world gross domestic product was 3 percent in 2018. India and China are the fastest growing economies among the developing economies since 2000. The growth of gross domestic product in China was 6.1 percent and 4.2 percent in India in 2019. It was the highest percentage growth among the developing countries. In the period between 2009 -2019, increase in the world export was 50 percent. The developing economies had recorded a notable increase in trade in the period between 2000 -2019. In the year 2000, the share of developing economies in the global trade was 29.7 percent which had increased to about 40 percent in 2019. In 2019, the share of Asian economies to the world exports was 24 percent. Among the Asian economies, China was ranked as first and India was ranked as second largest exporters of goods and services in 2019. Among the world economies, the annual carbon emission in China was 10150.82 million tonnes. It was the highest quantity among the world countries in 2016. India emitted 2430.8 million tonnes in 2016. It was the second largest quantity of carbon emission among the developing countries (World Bank, 2020). The studies (Cheng Lu,2017, Beyene and Kotosz, 2019, Ahmed and Long, 2012, Linh and Lin, 2014, Lopez et al 2014, Aye and Edoja, 2017**,** Mikayilov et al 2018, Muye Ru et al 2018, Ameer & Munir, 2016, Cetin et al 2018 and Yazdi & Dariani,2019) had proved the inter linkage between green house gas emissions, trade and economic growth. In this backdrop, the study on "**Relationship between Green House Gas Emissions, Trade Openness and Economic Growth – A Comparative Study between India and China"** was undertaken.

The following are the important research gaps identified in the earlier studies

1. In analyzing the greenhouse gas emissions, only carbon dioxide was taken into account in the earlier studies. But this study includes methane, nitrous oxide and four F gases along with carbon dioxide under greenhouse gas emissions as these gases also contribute to global warming.

2. Very limited studies had compared the relationship among greenhouse gas emissions, trade openness and economic growth between India and China for the period 1970-2018.
3. Impact of economic growth on greenhouse emissions has been studied vastly but the influence of greenhouse gas emissions on economic growth was assessed by very few earlier studies (Azam et al., 2016).
4. The decoupling classifications for India and China for 49 years were attempted in this study which was found in very few earlier studies.

The present study on "**Relationship between green house gas emissions, trade openness and economic growth- A comparative study between India and China"** tries to fulfill the above research gaps.

Objectives of the study

The following are the specific objectives of the study

1. To analyse the trend and growth of greenhouse gas emissions per capita, trade openness and gross domestic product per capita in India and China.
2. To assess the decoupling status of greenhouse gas emissions per capita and gross domestic product per capita, greenhouse gas emissions per capita and energy consumption per capita, greenhouse gas emissions per capita and trade openness.
3. To test the stationarity of greenhouse gas emissions per capita, gross domestic product per capita, trade openness and their determinants.
4. To study the cointegrating relationship among greenhouse gas emissions per capita, gross domestic product per capita, trade openness and their determinants.
5. To test the causal relationship among the greenhouse gas emissions per capita, gross domestic product per capita and trade openness

Hypotheses of the study

1. The variables chosen in the study are stationary
2. There exists long run relationship between gross domestic product per

capita and its determinants

3. There exists long run relationship between trade openness and its determinants
4. There exists long run relationship among the greenhouse gas emissions per capita and its determinants
5. Decoupling effects exist between greenhouse gas emissions per capita and gross domestic product per capita, greenhouse gas emissions per capita and energy consumption per capita, greenhouse gas emissions per capita and trade openness

Methodology

The study is based on secondary data collected from World Bank, emissions database for global atmospheric research and world resources institute websites. The carbon emission which is a major component of green house gas emission had increased by about 90 percent in the period between 1970- 2018. Therefore, the study is confined to the period 1970 - 2018. India and China are the fastest growing developing economies with large scale production, huge population, higher level of energy consumption, openness in trade and above all the world's largest emitters of green house gases. Therefore, India and China were selected for the present study.

The prime objective of the study is to find out the relationship between green house gas emissions, trade openness and economic growth. Green house gases emissions per capita included carbon dioxide emissions, methane emissions and nitrous oxide emissions. Gross domestic product per capita at constant prices expressed in US dollars is the proxy for Economic growth. Trade openness is the sum of exports and imports normalized by gross domestic product expressed in percentage. Green house gases emissions per capita is expressed in kilo tones. Trade openness is expressed in percentage. The present study is based on the theory of 'Limits to Growth' and EKC Hypothesis

Analytical Tools Applied

- Compound Growth Rate
- Tapio's Decoupling Analysis

- Augmented Dickey Fuller Test
- Johansen's Cointegration Analysis
- Vector Error Correction Model
- Grangers Causality Test
- Variance Decomposition Analysis
- Impulse Response Function

Findings of the study

Gross domestic product per capita in India and China

- For India, the average pace of per capita growth was 5.8 percent a year in the last decade which is stable and steady compared to China. The compound annual growth rate of GDP per capita for India is 3.39 percent and China is 7.29 percent during the study period.

Greenhouse gas emissions per capita in India and China

- The compound annual growth rate of greenhouse gas emissions in India is 3.35 percent and China is 4.41 percent.

Gross Fixed Capital Formation in India and China

- During 1970s, average annual growth rate of gross fixed capital formation (investment) of China was 7.6 percent, while India's investment growth rate was 2.7 percent only. Similarly in the decades of 90s, 2000, and 2010, China showed higher growth rate of 6 percent, 15.3 percent and 7 percent respectively in comparison to India.

Trade openness in India and China

- The trade openness growth rate in the five decades was fluctuating for India. The compound annual growth during 1970-2018 was 3.52 percent for India and 4.17 percent for China.

Energy consumption per capita in India and China

- The annual growth rate of energy consumption per capita has been the highest in the 1970s and 2000 to 2009 for China with 6.1 percent and 8.5 percent

respectively. The compound annual growth rate for India was 2.07 percent and for China, it was 3.79 percent..

Population in India and China

- There has been decline in population growth 1970 to 2018 in both India and China. The compound annual growth was negative with -1.49 percent for India and -3.53 percent for China.

Exchange rate in India and China

- The exchange rate of India in the first year of the study period 1970 was Rs.7.50 which increased to Rs 68.38 in 2018 bringing down the value of Indian Rupee against US Dollars. China's Yuan was valued at 2.46 in 1970 which increased to 6.61 Yuan only in 2018 showing more stability.

Inflation rate in India and China

- The inflation rate in India increased steadily to 8.47 percent in the 1970s and 8.7 percent in the 1980s. Inflation in India has declined steadily from an average of 8.7 percent in the 1990s to 5.7 percent during the decade of 2000. From 2010 to 2018, inflation fell to 5 percent.
- On the other hand, inflation in China has been comparatively low with 1.06 percent in 1970s, 4.7 percent in 1980s, 3.5 percent in the decade of 2000 and 2.8 percent in the last decade. Given the fact that Indian economy is severely marred by inflation, it seems unlikely that they will be able to compete against China in the long run.

Decoupling status

Decoupling status of Greenhouse gas emissions per capita and gross domestic product per capita in India and China

- In India during the period 1970-2018, majority of the years had weak decoupling status which means that as GDP increases, greenhouse gas emissions increase less than GDP. During the study period in China, it can be seen that weak decoupling was mostly found in about 27 years spread out.

Decoupling status of Greenhouse gas emissions per capita and energy consumption per capita in India and China

- .For both India and China, weak decoupling in majority of the years shows that pollution emissions growth is slower than the economic growth. This may be a welcome sign showing the shift to energy efficient and low polluting fuels used in the various spheres for the country's development. This energy efficiency shift has been due to the policy action of both the countries.

Decoupling status of Greenhouse gas emissions per capita and trade openness in India and China

- The decoupling status of greenhouse gas emissions per capita and trade openness in India showed that for 23 years the country had weak decoupling status. The relationship between trade openness and greenhouse gas emissions per capita was found to be strong negative decoupling in China for 13 year and weak decoupling for 15 years.

Long run relationship between GDP and its determinants using cointegration analysis

The ADF test

- Using the Intercept criteria the results showed the variables GDP per capita, GFCF per capita, trade openness, inflation energy consumption per capita, population and GHG emissions per capita became stationary only in their first differences for both India and China.
- The results of the unit root with trend and intercept pointed out clearly that the null hypothesis of a unit root can be rejected at the level for inflation for India and GHG emissions per capita and inflation for China.

Long run relationship- Cointegration test

- The Johansen and Juselius (1990) test of cointegration revealed that there were 6 cointegrating equations for India and China showing presence of long run relationship in the greenhouse gas emissions equation.
- The coefficients obtained revealed that trade openness and energy consumption per capita have positive impact on the GDP per capita in India during the study period. The remaining variables such as GFCF per capita, inflation, population and GHG emissions per capita have a negative effect on GDP per capita in India and GFCF per capita, trade openness, inflation, population and energy consumption per capita have negative impact on GDP per capita in China. The coefficient of energy consumption per capita is highest (0.28) in India implying that a one percent increase in energy consumption per capita will lead to 28 percent increase in GDP per capita. For China, energy consumption per capita and GHG emissions per capita have positive effects on GDP per capita in China. GFCF per capita, trade openness, inflation and population have negative impact on GDP per capita. The coefficient of GHG emission per capita has higher coefficient (0.58) in China implying that a one percent increase in GHG emissions per capita will lead to 58 percent increase in GDP per capita. The coefficients obtained from the cointegration equation clearly shows that GDP per capita during the study period for India is impacted by GFCF per capita, trade openness, population, inflation GHG emissions per capita and energy consumption per capita.

Short run relationship-Vector Error Correction Model (VECM)

- The error correction coefficient for GDP per capita as dependent variable for India was negative (-0.1476) indicating that the series for GHG emissions per capita will converge in the long run.
- For China the error correction coefficient of GDP per capita was negative (-0.29) showing the ability to go back to equilibrium in the long run.

- The estimated error correction model has the minimum goodness of fit with R^2 value being 0.59 and adjusted R^2 of 0.35 for India. For China, the R^2 was 0.43 and adjusted R^2 was 0.29

Variance Decomposition Analysis

- In the short run, 100 percent variance is explained by the variable itself meaning strongly endogenous. The remaining variables do not have any influence. From second period onwards, Inflation has an influence on GDP per capita both in the short run and in the long run.
- For China, 100 percent forecast error variance of GDP per capita is explained by itself in the short run. Population has a strong influence on GDP per capita from second period onwards, variance contribution of GDP per capita itself is 58 percent and population is 21.4 percent in the long run.

Impulse response Function

- For India, SD shock on GDP per capita will cause positive impact on GFCF per capita, energy consumption per capita and greenhouse gas emissions per capita in the short and long run. The innovation given on GDP per capita will cause an asymmetric impact on trade openness and inflation and a negative impact on population.
- For China, an SD shock on GDP per capita will cause an asymmetric impact on GFCF per capita, inflation and population. The shock on GDP per capita will cause positive impact on trade openness, energy consumption per capita and greenhouse gas emissions per capita.

Test of Stability- CUSUM and CUSUMSQ plot

The CUSUM and CUSUMSQ plot results revealed that GDP per capita was within the 5 percent critical bound levels, indicating that the gross domestic product was found to be stable throughout the study period for both India and China.

Long run relationship between Trade openness and its determinants (Gross domestic product per capita, gross fixed capital formation per capita, exchange rate and population) using cointegration analysis

The ADF test

- The ADF unit root test of stationarity results are as follows. Using the “Intercept” and “Trend and intercept” criteria the results indicated that the variables GDP per capita, GFCF per capita, exchange rate, population and trade openness became stationary only in their first differences for India and China.

Long run relationship- Cointegration tests

- The Johansen and Juselius (1990) test of cointegration revealed that there were 1 cointegrating equation for India and 2 for China showing presence of long run relationship in the trade openness equation
- The coefficients obtained revealed that GFCF per capita and exchange rate have negative impact on trade openness in India during the study period. The coefficients obtained for China revealed that GFCF per capita and population have negative impact on trade openness during the study period.

Short run relationship-Vector Error Correction Model (VECM)

- The error correction coefficient for trade openness as dependent variable for India was negative (-0.0081) indicating that the trade openness emissions series will converge in the long run. For China, the error correction coefficient for trade openness was negative (-0.0546) indicating that GHG Emissions series will converge in the long run.
- The estimated error correction model has the minimum goodness of fit with R^2 value being 0.25 and adjusted R^2 of -0.06 for India. For China, the R^2 was 0.32 and adjusted R^2 was 0.04

Variance Decomposition Analysis

- In the short run, 100 percent variance is explained by the variable itself meaning strongly endogenous. The remaining variables do not have any influence.

- For China, 100 percent forecast error variance of trade openness is explained by itself in the short run. GFCF per capita has a strong influence on GDP per capita from second period onwards.

Impulse Response Function

- The IRF of GDP is negative both in the short run and long run for India implying that GDP per capita has negative influence on trade openness. For China the response is positive both in the short run and long run supporting the view that trade openness is one of the important reasons for its faster growth. The GFCF per capita is negative both in the short run and long run for India and China. The population variable is positive throughout the period in both India and China. The response of exchange rate (ER) is stable initially and stays in the positive region in the long run for India. For China, the exchange rate response was positive in both short run and long run.

Test of Stability- CUSUM and CUSUMSQ plot

The CUSUM and CUSUMSQ plot results showed that trade openness was within the 5 percent critical bound levels, indicating that the trade openness was found to be stable throughout the study period for both India and China.

Long run relationship between Greenhouse gas emissions and its determinants using cointegration analysis

The ADF test

- The ADF test of stationarity for the selected determinants of greenhouse gas emissions such as GDP per capita, GDP per capita square, GHG per capita, energy consumption per capita and trade openness was carried out. In the intercept criteria of Unit root test, the results indicated that all the variables GDP per capita, GDP per capita square, GHG per capita, EN per capita and trade openness became stationary only in their first differences for India and China.
- The results of the unit root with trend and intercept revealed that the null hypothesis of unit root was rejected in the first difference at 5 percent level of significance for all the variables such that that GDP per capita, GDP per capita

square, GHG emissions per capita, energy consumption per capita and trade openness were found to be stationary at their first differences for India and China.

Long run relationship-Cointegration Test

- The Johansen and Juselius (1990) test of cointegration revealed that there were 3 cointegrating equations for India and China showing presence of long run relationship in the greenhouse gas emissions equation.

  The coefficients obtained revealed that GDP per capita and GDP per capita square have positive impact on the GHG emissions per capita in India and GDP per capita, energy consumption per capita and trade openness have positive impact on GHG emissions per capita for China in the long run. Energy consumption per capita and trade openness have a negative effect on GHG emissions per capita for India and for China. GDP per capita square has negative effect on GHG emissions per capita. .

- The study found that for China, the effects of GDP per capita and GDP per capita square on greenhouse gas emissions per capita are positive and negative respectively thus confirming the inverted U shape for the study period in accordance with EKC theory But for India there is no evidence of such a relationship between greenhouse gas emissions per capita and gross domestic product.

Short run relationship-Vector Error Correction Model (VECM)

- The error correction coefficient for GHG emissions per capita as dependent variable for India was negative (-0.4860) as in the theory indicating that the series for GHG emissions per capita will converge in the long run. For China It was found that the error correction coefficient for GHG emissions per capita was negative (-0.2917) indicating that the series for GHG emissions per capita will converge in the long run.

- The estimated error correction model has the minimum goodness of fit with R^2 value being 0.48 and adjusted R^2 of 0.39 for India. For China, the R^2 was 0.66 and adjusted R^2 was 0.51

Variance Decomposition Analysis

- The variance decomposition results showed that in the short run 100 percent variance is explained by the variable itself meaning strongly endogenous. The remaining variables do not have any influence.
- For China, 100% forecast error variance of GHG emissions per capita is explained by itself in the short run. Energy consumption per capita has a strong influence on GHG emissions per capita from second period onwards.

Impulse Response Function

- The impulse response function of GDP pc in both India and China is almost the same. In India, it initially increases in the short run, then declines in the 2nd period, becomes stable while nearing the 5th period attains negative region after that. In China the response of GDP pc is positive and increasing till 2nd period, declines in the third period, becomes stable in the short run and attains negative in the long run. The response of GDP pc^2 initially is positive but gradually falls till period 9 and becomes negative in the 10th period for India. In the case of China, the IRF of GDP pc^2 is same as the response of GDP pc, first it is positive and stable and then becomes negative in the long run. It can be inferred that in India any shock on greenhouse gas emissions will cause a positive impact on gross domestic product per capita square and energy consumption per capita and negative effect on trade openness. An innovation on greenhouse gas emissions will cause an asymmetric impact on gross domestic product per capita in India. For China an innovation on greenhouse gas emissions per capita will cause an asymmetric impact on GDP per capita, GDP per capita square, energy consumption per capita and trade openness. The figure clearly shows how the economic growth inhibits greenhouse emissions in the long run especially for China supporting the EKC hypothesis but the decoupling happened to be slower

in India comparatively. GDP pc ^{2} in India and China shows the same effects as their GDP pc responses.

Test of Stability- CUSUM and CUSUMSQ plot

- The CUSUM and CUSUMSQ plot results revealed that the CUSUM plot for GHG per capita was within the 5 percent critical bound levels, indicating that the greenhouse gas emissions was found to be stable throughout the study period for both India and China. The CUSUMSQ plot revealed that there was evidence of stability for India and China, some period in 80s showed instability.

Granger's Causality

Granger's causality revealed unidirectional relationship between the following variable pairs for India such as

- Gross domestic product per capita & greenhouse gas emissions per capita,
- Gross domestic product per capita square and greenhouse gas emissions per capita
- Energy consumption per capita and greenhouse gas emissions per capita,
- Gross domestic product per capita square and trade openness

For China the following pairs had unidirectional relationship.

- Gross domestic product per capita and greenhouse gas emissions per capita
- Gross domestic product per capita square and greenhouse gas emissions per capita
- Trade openness and greenhouse gas emissions per capita
- Trade openness and gross domestic product per capita square
- Trade openness and energy consumption per capita.

The pairs which showed bidirectional causality were

- Gross domestic product per capita square &gross domestic product per capita.

The causality running from gross domestic product per capita to greenhouse gas emissions in both India and China revealed that all steps taken to improve growth will

increase the emissions. When the countries grow the consumption of energy is more and therefore emissions increase as can be seen from the unidirectional causality between energy consumption per capita and green house gas emissions per capita in both India and China. The results for China clearly show how trade openness is the cause for increase in gross domestic product per capita, energy consumption per capita and green house gas emissions per capita similar to the finding by Jun et al,2020.

Conclusion

This study looked at the presence of long run relationships among greenhouse gas emissions per capita, trade openness and gross domestic product per capita in both India and China. Results from cointegration analysis using VECM indicate presence of long run relationship among the variables at all conventional levels of significance. The study confirmed the existence of inverted U shaped EKC hypothesis for the study period in China in accordance with EKC theory and empirical research by Jalil and Mahmu (2009), Halkos, G. and Tzeremes(2011), Xu et al. (2018), Hao et al. (2019). But for India there is no evidence of such a relationship between greenhouse gas emissions per capita and gross domestic product similar to the results of Makarrabbi et al. (2017).The existence of EKC in China guarantees the definitive improvement in the environment along the trade openness path.

Decoupling analysis shows that decoupling happens in both the countries but it is ‘weak decoupling’ for majority of the years indicating the need for stronger commitment to shift to energy efficient methods of production. Results based on granger causality show evidence of a Granger causality running from GDP per capita to greenhouse gas emissions per capita for both India and China cautioning that environmental conservation policies should aim at reducing emissions of all the greenhouse gases including non carbon emissions too without sacrificing economic growth. This implies that both the economies should pursue energy conservation policies and greenhouse gas emission reduction policies in the long run without compromising economic growth. This calls for policy makers to consolidate the policy framework to ensure the economy is grown sustainably.

References

- Ahmed, K. and Long, W. ,(2012), “Environmental Kuznets Curve and Pakistan: An empirical analysis”. Procedia Economics and Finance, Vol 1, Pp 4-13.
- Ameer, A. and Munir, K., (2016), “Effect of Economic Growth, Trade Openness, Urbanization, and Technology on Environment of Selected Asian Countries”, MPRA Paper No. 74571, Pp 1-35.
- Aye, G.C. and Edoja, P.E., (2017) “Effect of economic growth on CO_2 emission in developing countries: Evidence from a dynamic panel threshold model”. Cogent Economics and Finance, Volume 5, Issue 1, Pp1-22.
- Azam ,M., Khan, A.Q., Abdullah, H.B. and Qureshi, M.E., (2016), “The impact of CO2 emissions on economic growth: evidence from selected higher CO2 emissions economies”, Environment Science and Pollution Research, Vol 23, Issue 7, Pp. 6376-6389.
- Beyene, S.D. and Kotosz, B., (2019), “Testing the Environmental Kuznets Curve Hypothesis: An empirical study for East African countries”, International Journal of Environmental Studies, Vol 77, Issue 4, Pp 636-654.
- Cetin, M.A. (2017), “Investigating the Environmental Kuznets Curve and the role of green energy: Emerging and developed markets”, International Journal of Green Energy, Vol 15, Issue 1, Pp 37-44.
- Cheng Lu, W(2017), “Greenhouse Gas Emissions, Energy Consumption and Economic Growth: A Panel Cointegration Analysis for 16 Asian Countries”, International Journal of Environmental Research and Public health, Volume 14, Issue 11, Pp 1-15.
- Emissions database for global atmospheric research (2021), European Environment Agency, Copenhagen, Denmark.
- Energy Technology perspectives, (2015), International Energy Agency, Paris.
- Forster, P. et al (2007), “Changes in Atmospheric Constituents and in Radiative Forcing”, Contribution of Working Group I to the Fourth Assessment Report of the IPCC, Cambridge University Press, Cambridge, UK.

- Grossman, G.M. and Krueger, A.B., (1991), "Environmental Impacts of a North American Free Trade Agreement," NBER Working Paper No. 3914, National Economic Bureau of Research, Cambridge, MA Pp1-57.
- Kuznets,S (1955), “Economic Growth and Income Inequality”, The American Economic Review, Vol 45, No 1, Pp 1-28.
- Linh, D.H. and Lin, S.M (2014), “CO2 Emissions, Energy Consumption, Economic Growth and FDI in Vietnam”, Managing Global Transitions, Vol. 12, Issue 3, Pp 219–232.
- López, R., Gregmar I. and Galinato, (2005), “Deforestation and Forest-Induced Carbon Dioxide Emissions in Tropical Countries: How Do Governance and Trade Openness Affect the Forest-Income Relationship?” The Journal of Environment and Development, Vol 14, Issue 1, Pp-73-100.
- Mikayilov, J.I.., Galeotti, M. and Hasanov,F..J. (2018), “The Impact of Economic Growth on CO2 Emissions in Azerbaijan”, Ecological Indicators, Vol 95, Issue,1, Pp 615-628.
- Ru, M., Shindell, DT., Seltzer, K.M., Tao, S. and Zhong,Q. (2018), “The long-term relationship between emissions and economic growth for SO_2, CO_2, and BC”, Environment Research Letters, Vol 13, Issue 12,Pp-1-11.
- Shahbaz, M., Nasreen, S., Ahmed, K. and Hammoudeh, S. (2017), “Trade openness–carbon emissions nexus: The importance of turning points of trade openness for country panels” Energy Economics, Vol61, Pp 221-232.
- Sun, H., Clottey, S.A., Geng,Y., Fang,K. and Amissah, J.C.K. (2019), “Trade Openness and Carbon Emissions: Evidence from Belt and Road Countries”, Vol 11, Issue 9, Pp 1-20.
- World Bank.Report, (2020), The World Bank Group, Washington
- Yazdi, S.K. and Dariani,A.G. (2019), “CO 2 emissions, Urbanisation and Economic growth: Evidence from Asian countries”, Economic Research, Vol 32, Issue 1, Pp-510-530.